Glass Aggregate Feasibility Study

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PROBLEM STATEMENT: Contaminated sediment is a common problem throughout Areas of Concern within the Great Lakes Basin. Contaminated sediments significantly contribute to the impairment of nearly all identified beneficial uses. Dredging of sediments is frequently done to improve environmental conditions where contaminated sediments pose unacceptable risk to human and ecological health. The Great Lakes ecosystem health depends on, among other things, the elimination of contaminants or, where appropriate, a high level of permanent isolation. Removal of contaminated sediments from the ecosystem is often the preferred action because it permanently eliminates this exposure pathway to aquatic resources.

Where to place contaminated dredge material is a question in search of answers. Historically, in water or upland Confined Disposal Facilities (CDF) have been utilized as final resting places for contaminated dredge materials. However, CDFs are not appropriate for placement of all dredge material. For example, dredge material containing greater than 50 parts per million (ppm) Polychlorinated Biphenyl (PCB) must be disposed of in a landfill approved under the Toxic Substances Control Act (TSCA). Placement of contaminated dredge material in CDFs and landfills requires public acceptance. Recent experience in Wisconsin with the approval of the Fort James Landfill Cell 12A to take TSCA level dredge material and the proposed expansion of the Renard Island CDF in Green Bay illustrates the difficulties in gaining public acceptance for these methods.

Similar points have been made in response to WDNR's February 1999 release, for public comment, of a draft Remedial Investigation/Feasibility Study (RI/FS) for addressing the contaminated sediments in the Lower Fox River. Both *in situ* and *ex situ* remedial alternatives were evaluated for their ability to break the contaminant exposure pathway. WDNR received numerous comments on the draft RI/FS. Several of the comments requested that the use of PCB destruction technologies be given additional review and wider use in the proposed cleanup alternatives. Also, more comments were received supporting *ex situ* cleanup options than *in situ* options.

Beneficial use is the general term that describes alternatives for managing dredge material by focusing on its value as a resource and not as a waste. Converting river sediment into glass aggregate, technically known as vitrification, provides effective solutions to both the destruction of contaminants and disposal issues. A vitrification process has been successfully demonstrated on contaminated New York/New Jersey Harbor sediments funded through the Water Resources Develop Act (WRDA). Eliminating the disposal issue from the cleanup equation removes a significant hurdle from the path of *ex situ* cleanup options. Providing acceptable and cost effective disposal of contaminated sediment will allow for more complete and effective cleanups.

PARTNERSHIPS: One set of Lower Fox River RI/FS comments were received from Minergy Corp. (Minergy). Minergy currently operates a glass aggregate facility on the banks of the Lower Fox River. This facility presently incinerates (burns) paper mill sludge into glass aggregate that is subsequently sold primarily as fill material although other options do exist for use of the material. Minergy's comments suggested that a vitrification (melting) technology may be more appropriate for the treatment of sediment contaminants. WDNR contacted Minergy as a follow-up to their RI/FS comments. Minergy prepared a proposal for a multi-phased study to determine the cost effectiveness of this technology and the treatment effectiveness to destroy organic contaminants (primarily PCB) and immobilize inorganic contaminants (primarily mercury). Minergy proposed a four phased feasibility study for the testing of a glass furnace sediment melting system.

The four phases are:

Phase I: Mineralogy and sediment characterization
Phase II: Crucible melt and preliminary design engineering
Phase III: Pilot scale sediment melt of dewatered dredge material
Phase IV: Full-scale facility construction.

Minergy also proposed a cost-sharing schedule by which a Minergy /WDNR partnership would complete the feasibility study.

Recognizing the extreme scrutiny PCBs have been under and the need for a thorough evaluation of the destruction efficiencies, WDNR requested assistance from US EPA's Superfund Innovative Technologies Evaluation (SITE) Program. US EPA's SITE Program has accepted the challenge of conducting the cost and treatment effectiveness evaluations (Appendix A).

WORK COMPLETED TO DATE: Minergy and WDNR have successfully completed Phases I and II of this feasibility study. The first phase (Phase I) was to characterize the mineral composition of river sediments to estimate the glass quality, durability and melting points (Table 1.). Phase I conclusions include that river sediment characteristics are very consistent throughout the river and are very favorable for producing a quality glass product. Further, vitrification technology is more appropriate for river sediments than incineration as demonstrated by the low Loss on Ignition analyses

Phase II of the project, crucible melts of actual Lower Fox River sediment, were conducted to determine the actual melting conditions and glass characteristics/qualities of the sediment alone and when augmented with other materials (flux mixtures). Four different test "recipes" were included in the crucible melts and the sediment successfully melted into glass in all four tests. Phase II results include a proposed recipe for melting river sediment into glass aggregate and preliminary engineering designs for the pilot test facility proposed for Phase III (Appendix B). This preliminary engineering recommended not to use an existing glass furnace for Phase III testing. Results of Phase II testing indicate that the cost to retrofit an existing facility to the specification needed to melt the sediment would be as much as building a pilot melter to those same specifications. Also, most existing facilities are too large to accommodate a limited duration test.

Results of Phase I and II testing indicate that the glass furnace capital and operating costs could allow the processing and melting of the river sediments to be considered an economically viable option.

In anticipation of Phase III, approximately 70 tons of dewatered dredge material have been secured from the 1999 pilot dredging project at SMU 56/57 in the Lower Fox River. This non-TSCA material is being stored temporarily in a secure location for use as the feedstock for Phase III testing.

Minergy Corp., WDNR, US EPA SITE, US EPA SITE contractors and US EPA GLNPO staff have participated in an initial meeting (January 2000) to discuss the work completed to date and the scope of the US EPA SITE evaluation. Follow-up discussions have occurred on a regular basis between Minergy, WDNR and SITE (staff and contractors) to discuss SITE's development of the Quality Assurance Project Plan (QAPP).

PROPOSED PROJECT OBJECTIVES: Overall, Phase III of the feasibility is intended to accomplish the following objectives:

1. Permitting Information. One of the key objectives of Phase III study is to obtain sufficient data in the area of air emissions and PCB destruction in the melter in order for a thorough and complete evaluation of all required permits for any commercial scale project.

2. Full Scale Melter Design Parameters. Data obtained from the pilot test should validate proper melter design to allow the melter to be scaled up to the full-scale unit. Data obtained from the pilot melter should validate proper dimensional requirements and operating depth of the molten glass pool as well as proper refractory selection and burner size and location.

3. Sediment Batching and Flux Optimization. The pilot testing will help determine the proper amount and type of flux to be used in the melter. Various fluxing agents will be evaluated to determine the heat input requirements, glass product property, and flux system capacity.

4. Selection and Testing of the Sediment Drying Technology. The melter will require river sediments to be relatively dry, > 90% solids, prior to loading into the melter. Dredged sediments that are mechanically dewatered can only be expected to approximate 50% solids. Phase III includes review of appropriate drying technology and testing of the preferred drying technology to verify contaminant fate.

In support of Objectives 1, 2, and 4, US EPA SITE has tentatively developed the following primary objectives:

P1. Determine the Destruction and Removal Efficiency (DRE) of Polychlorinated Biphenyls (PCBs) in the Glass Furnace Technology (GFT) in dredged-and-dewatered river sediment.

P2. Determine whether the GFT aggregate product meets the criteria for beneficial reuse under relevant federal and state regulations.

In addition, secondary objectives include:

S1. Determine the unit cost of operating the GFT on dredged-and-dewatered river sediment.

S2. Quantify the organic and inorganic contaminant losses resulting from the existing or alternative drying process used to dry the dredged-and-dewatered river sediment

S3. Characterize organic and inorganic constituents in all GFT process input and output streams.

PROPOSED SCOPE OF WORK: The preliminary engineering conducted in Phase II testing indicates that operating a pilot scale oxy-fueled glass furnace for two weeks will provide the necessary operational data to scale up to a full scale melter. The requested funding will be used to design and operate a pilot scale oxy-fueled glass furnace to generate this operational data and determine the cost and treatment effectiveness of this technology. US EPA GLNPO funds would not be used to fund the actual construction of the melter. Minergy's proposed cost share would fund this aspect of the project (see Project Budget).

The preliminary design for the pilot scale melter to be built is included in Appendix B. This melter will be operated 24 hours a day for two weeks. Operating around the clock, the melter will produce approximately 2 tons of glass aggregate per day. This equates to the daily use of approximately 4 tons of dewatered dredge material containing 50% solids.

As indicated in the preliminary design drawing in Appendix B, the Phase III oxy-fueled melter is a refractory box supported by structural steel. The burners are connected to the side of the melter heat and melt the feedstock. The dry river sediment is fed in through a water cooled screw. This design is very typical and is used in almost all glass furnaces. Molten material is drained from the back of the melter. Exhaust gases produced during the melting processes are vented out of the stack. Due to he fairly relatively low gas volumes produced by the oxy-fuel melter and the large volume of gas space above the molten line, gases remain resident in the melter for a significant period of time. The typical operating temperatures in the melter will be between 2600^{o} F and 2900^{o} F. This should provide complete destruction of all organic materials including PCB's. In addition, any trace metals in the molten glass will be stabilized when it is quenched and the glass matrix is formed.

Recognizing the need to further dry the dewatered dredge material to achieve > 90% solids and the reported volatilization potential of PCBs, a secondary activity will be to review and select appropriate dryer technology. Through appropriate design of a full scale facility, any losses due to drying can be minimized and controlled. However, at the proposed pilot scale this can not be achieved. Therefore, this project also includes a review of available dryer technology and an evaluation of the selected technology. Because commercial dryers are not typically built to accommodate an evaluation of losses through the process, this project will evaluate the losses through the selected dryer technology at the bench scale. A limited representative sub-sample of the available dewatered sediment will be tracked through a bench scale dryer system.

DELIVERABLES: The project, when completed, will provide a complete evaluation of the cost and treatment effectiveness of the glass furnace technology to commercially produce an unrestricted reusable glass aggregate by-product. In addition, the necessary operational data will be generated to design, construct and operate full-scale facility. This information will be made available in the following deliverables:

1. QAPP. In order to complete the proposed objectives, high quality chemical information will be generated. US EPA SITE Program will develop the Quality Assurance Project Plan for the project elements necessary to evaluate the treatment objectives defined above. A relational database will be developed for this project and incorporated into the web-searchable Lower Fox River Database compiled for the RI/FS.

2. Design and Operation Report. This report will summarize the actual design, construction and operation of the pilot melter. Included will be such topics as: emission projections, qualitative discussions of observations of the melter operations and post refractory inspection, optimum flux selection, basis for preferred dyer system and design basis documents for a full scale processing line.

3. US EPA SITE Program's evaluation of the cost and treatment effectiveness of the glass furnace technology. This report will also include the evaluation of contaminant losses through the selected drying process.

4. WDNR will post and maintain a project website and database.

5. All the glass aggregate you want.

PROJECT SCHEDULE: The schedule is dependent on several factors. These factors include but are not limited to:

- finalizing contracts between WDNR and Minergy
- securing permits and local approvals
- availability or manufacturing of the necessary refractory.

At present, it is anticipated that the actual melting of river sediments would occur within 6 months after completing the contract between WDNR and Minergy. It is also anticipated that draft reports would be available within 6 to 12 months (primarily dependent on analytical results) after completing the test melt.

PROJECT BUDGET: The budget based on Minergy's original cost-sharing schedule can be broken down into the following:

Project Element	Estimated Cost	Minergy	EPA GRANT ($ 265,000 Total)		State Funds	US EPA SITE
			GLNPO	WDNR		
Design	$ 150,000		$ 75,000		$ 75,000	
Furnace Construction	$ 363,000	$ 363,000				
Sediment Drying	$ 100,000		$ 50,000		$ 50,000	
Furnace Operations	$ 250,000		$ 125,000		$ 125,000	
Project Management	$ 15,000			$ 15,000		
Totals:	$ 878,000	$ 363,000	$ 250,000	$ 15,000	$ 250,000	
Treatment Efficiency Evaluation	???					ALL

This grant proposal requests a total funding share of $250,000 from US EPA GLNPO. US EPA GLNPO and State funds will be used to exicute a single contract with Minergy Corp. to complete the entire project. WDNR will provide project and contract management through existing staff assignments. GLNPO grant funds and additional State funds will be used for the design of the furnace, drying the sediment and the operation of the furnace during the actual 2 week test melt. If cost over runs occur, WDNR will not request additional funds from US EPA GLNPO.

APPENDIX A

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